REMARKS

This Preliminary Amendment cancels without prejudice claims 1 to 6 in the underlying. PCT Application No. PCT/DE03/03514, and adds without prejudice new claims 7 to 12. The new claims, *inter alia*, conform the claims to United States Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.125(b), the Substitute Specification (including the Abstract) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to United States Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. §§ 1.121(b)(3)(ii) and 1.125(c), a Marked-Up Version of the Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

The underlying PCT Application No. PCT/DE03/03514 includes an International Search Report, dated February 24, 2004. The Search Report includes a list of documents that were uncovered in the underlying PCT Application. A copy of the Search Report accompanies this Preliminary Amendment.

It is asserted that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,

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ANGLE-RESOLVING ANTENNA SYSTEM

FIELD OF THE INVENTION

The present invention relates to an angle-resolving antenna system.

~~Background Information~~ BACKGROUND INFORMATION

Pulse radar systems ~~are commonly~~ may be used for the determination of the speed and distance of objects in street traffic~~(WO 99/42856).~~, as in, for example, International Published Patent Application No. 99/42856.

~~DE 44 12 770 A1 discloses~~ German Published Patent Application No. 44 12 770 discusses that overlapping antenna lobes may be produced for a motor vehicle distance-warning radar in which the beam lobes may also be swiveled. Either an exciter system is used there as the transmitting and receiving antenna, or a separate transmitting and receiving antenna is provided.

~~WO 02/15334 discloses~~ International Published Patent Application No. 02/15334 discusses a multi-beam antenna array ~~having~~ including a beam-shaping network and a beam-combining network. Measures are taken there to have the transmitting and receiving lobes point in exactly the same direction.

~~Advantages of the Invention~~ SUMMARY OF THE INVENTION

~~The measures of Claim 1, i.e.,~~ The present invention provides for two radar sensors for the determination of distance and angular deviation each ~~having~~ including a separate transmitting and receiving antenna, receiving antennas for the two radar sensors switchable with reference to their main beam

direction as well as to their beam width, and an evaluation ~~means~~ arrangement for obtaining the angular deviation from the receiving signals of the two radar sensors in unlike switching states of their receiving antennas, may allow the number of radar sensors, in particular for the determination of angular deviation, to be reduced. Two different receiving antenna characteristics give information concerning the angular deviation of a target.

In addition to the evaluation of angular deviation using only two radar sensors, an increase in range is obtained. Switching, i.e., free selection of antenna characteristics with reference to their main beam direction and beam width, results in great flexibility for a variety of applications, e.g., ACC, TWD, PP, in the close and far range. When the additional antenna exciter arrays are switched off, the antenna system is still capable of delivering its usual performance.

~~Advantageous embodiments are described in the subclaims.~~

~~Drawings~~

~~Exemplary embodiments of the present invention are explained with reference to the drawings.~~

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a radar sensor ~~having~~ including a transmitting and a receiving antenna array in each instance~~,~~.

Figure 2 shows an antenna characteristic in the azimuth direction for transmitting and receiving antenna~~,~~.

Figure 3 shows a variety of target scenarios with switchable antenna characteristic of a receiving antenna~~,~~.

Figure 4 shows a target situation with antenna characteristics of three radar sensors without switching of the antenna characteristics~~,~~.

Figure 5 shows the target situation of Figure 4 using two radar sensors with switching of the antenna characteristics~~,~~.

Figure 6 shows antenna characteristics with two switchable radar sensors and antenna characteristics pointing outward with reference to the receiving antenna having a narrow beam width~~,~~.

Figure 7 shows a radar sensor with alignment of the antenna characteristics having a narrow beam width in the direction of the sensor axis~~,~~.

Figure 8 shows antenna characteristics of two arrays of patch antennas~~, and~~.

Figure 9 shows the ~~design~~ configuration of a patch antenna array and the signal evaluation.

~~Description of the Exemplary Embodiments~~

DETAILED DESCRIPTION

Figure 1 shows ~~a known~~ an antenna arrangement ~~having~~ of another system including a column 1 of four patch exciters for transmitting and a column 2, separate therefrom, of four patch exciters for receiving. A single patch exciter has a beam angle of about 90°.

If, as here, a plurality of patches, for example four patches, are located in a column, the vertical antenna beam angle (elevation) is reduced by the number of antenna elements. With the four patch exciters of Figure 1, a vertical beam angle of 30° is obtained. In the horizontal direction (the azimuth),

nothing is altered with respect to a single exciter, i.e., the beam angle is 90°. The antenna characteristics associated with Figure 1 are shown in Figure 2. The antenna characteristics for transmitting and receiving in the azimuth are practically the same.

Now, if one or more columns are combined into one receiving-antenna array, beam shaping may also be executed in the azimuth. The antenna diagram may be swiveled when the individual columns are in addition controlled separately by signals displaceable in phase. For this purpose, phase shifters 3 with unlike time lags may be provided for each column (Figure 9, whose output signals are processed together in evaluation unit 4, in order to determine the angular deviation from the receiving signals of the two radar sensors in unlike switching states). Switch-off or switch-on of antenna columns may ~~likewise~~ be varied in the antenna diagram, i.e., the antenna characteristic. Two columns that are capable of being switched on and ~~have~~ include four patch exciters each are shown in Figure 9.

Switching the receiving antenna characteristics ~~allows~~ may allow the number of radar sensors to be reduced. Two different receiving antenna characteristics permit information concerning the angular deviation of a target to be obtained. Various target scenarios are shown in Figure 3. Thus, in addition to distance information, the angular deviation is obtained. The switchable antenna diagrams of the receiving antennas for separation of the two targets are shown in Figure 3.

Figure 4 shows the ACC-stop-and-go situation using three radar sensors without antenna switching. At least three radar sensors 5, 6, and 7 are required in order to be able to react specifically to two targets using triangulation.

Figure 5 shows the same situation, controlled according to the present invention by two radar sensors 8 and 9, specifically by ~~designing~~ configuring the receiving antennas of radar sensors 8 and 9 as switchable with reference to their main beam direction as well as to their beam width, in particular by switching antenna columns 2, 21, 22 on and off (Figure 9) and corresponding phase control. The two narrow lobes, i.e., the antenna characteristics having a narrow beam width, are swiveled out of the sensor axis, i.e., toward the midperpendicular of the two radar sensors, in the direction of the center of the vehicle. An increase in range directly in front of the vehicle is thereby obtained.

The ~~following advantages of the~~ arrangement in Figure 5 ~~as compared with the arrangement in Figure 4 are obtained.~~ may provide for:

- Rough angular resolution of a single sensor,
- Reduction in the number of radar sensors,
- Increase in range,
- Switching, i.e., free selection of the antenna characteristic, results in greater flexibility (ACC, TWD, PP).

The antenna columns are switched on or off depending on the application. When additional columns are switched off, the radar sensors continue to be capable of delivering the same performance, as ~~can~~ may be seen in Figure 2. There a variation of the known amplitude monopole method is shown with antenna lobes that are not swiveled.

The case with lobes turned outward with reference to the narrow beam widths is shown in Figure 6. This arrangement permits precise detection at the edges of the vehicle path in forward as well as in reverse direction. It is of course alternatively possible to align the narrow antenna lobes in

the direction of the sensor axis (Figure 7). The same ~~advantage~~ feature as described above is obtained by skillful selection methods. Two targets ~~can~~ may be specifically allocated in combination with the second radar sensor (Figure 8). The increased gain of the antenna increases the range of the radar sensor. In addition, switching of the antenna characteristics (lobes) permits optimal use of the radar sensor in the close range and in the far range. The antenna characteristic remains constant, so that the transmitting power need not be switched. This ~~might possibly~~ may be ~~necessary~~ for approval reasons.

As Figure 9 shows, the receiving antenna ~~has~~ includes an array of individual patches. Triggering of the antenna columns gives information concerning the mode of operation. Either the signal phases are switched and a swivelable antenna lobe is present, or the columns are switched on and a distinct change in the beam angle of the receiving antenna is present.

The antenna system according to the present invention ~~is advantageously~~ may be suitable for angular resolution in pulse radar applications of automotive technology, but alternatively may ~~advantageously~~ be used for other applications.

~~Abstract~~

ABSTRACT OF THE DISCLOSURE

For an angle-resolving antenna system, only two radar sensors ~~(8, 9)~~ are provided ~~having~~ including separate transmitting and receiving antennas. The receiving antennas ~~(1, 21, 22)~~ of the two radar sensors ~~(8, 9)~~ are switchable with reference to their main beam direction as well as to their beam width.

~~(Figure 9)~~